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Manaaki Whenua
Landcare Research

Identification of major sediment sources in the Motueka River

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Identification of major sediment sources in the Motueka River

Motueka Integrated Catchment Management
(Motueka ICM) Programme Report Series

by

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Cover Photo: Upper reaches of the Wangapeka River.

PREFACE

An ongoing report series, covering components of the Motueka Integrated Catchment Management (ICM) Programme, has been initiated in order to present preliminary research findings directly to key stakeholders. The intention is that the data, with brief interpretation, can be used by managers, environmental groups and users of resources to address specific questions that may require urgent attentin or may fall outside the scope of ICM research objectives.

We anticipate that providing access to environmental data will foster a collaborative problem-solving approach through the sharing of both ICM and privately-collected information. Where appropriate, the information will also be presented to stakeholders through follow-up meetings designed to encourage feedback, discussion and coordination of research objectives.

Part of the aim of the project "Sediment generation from alternative land-uses and landforms in the Motueka valley" is to determine the spatial pattern of sediment generation and sediment delivery into the Motueka River from different erosion processes. This work complements other research in the project, namely:

- measurement of sediment yield at 3 key sites in the catchment (Hicks and Merrilees 2003); the main stem at Woodmans Bend (gives total sediment load to Tasman Bay), Wangapeka at Walters Peak (gives sediment load from high-rainfall, mountainous catchments on basement rock), Motupiko at Christies Bridge (gives sediment load from low-rainfall, hilly catchments on Moutere gravel);
- analysis of historic river cross section data from the upper and lower Motueka (Sriboonlue and Basher 2003);
- review of existing data on erosion rates and sediment yield for the Motueka catchment (Basher and Hicks 2003).

Together these research components work towards compiling a sediment budget for the catchment, from which future options for managing sediment load could be derived. In particular this part of the project aims to determine the relative significance of hillslope sources (such as landslides and gullies) and bank sources to sediment yield, the spatial pattern of sediment sources and their relationship with factors such as geology and land use/vegetation cover.

During 2002/03 two main activities were undertaken: a reconnaissance aerial survey of the catchment to provide an overview of erosion processes in the entire catchment, initiation of mapping of sediment sources. Results of this work are briefly outlined.

1) Aerial survey

In October 2002 a reconnaissance aerial survey of the catchment was undertaken to provide an overview of the dominant type of erosion processes in the catchment, and the variation in erosion processes within the catchment. Some impressions from this survey are listed below.

a) Landsliding

High areal density of landsliding is restricted to a very small area of the catchment in the north branch headwaters of the Wangapeka River (Fig. 1). Here there is a very high density of debris slides, often extending from ridge crest to valley bottom and characterised by complete failure of the regolith and exposure of bedrock[1]. Rocks are mapped as Greenland Group sandstone, siltstone and mudstone. These landslides appear similar in form and age to the abundant landslides in the Matiri and Karamea Rivers formed during the 1929 Murchison earthquake (Pearce and O'Loughlin 1985; Pearce and Watson 1986).

Fig. 1 High density of landslides in the north branch headwaters of the Wangapeka River

Throughout the rest of the Wangapeka there was a low density of landsliding, including the Dart catchment on Separation Point granite (Fig. 2), which has frequently been suggested as a major contributor of sediment. The landslides and riparian sources (Fig. 3) observed in the Dart catchment were dominantly in areas under native forest rather than pine. The Baton, Pearse, Graham and Pokororo catchments had an extremely low density of landslides (Fig. 4).

[1] Interestingly this contrasts with the NZLRI that shows an area of extreme soil slip erosion in the south branch headwaters of the Wangapeka on younger Matiri and Mangles formation sediments, where we observed minor landsliding.

Fig. 2   Low density of landslides in upper Dart River in native forest

Fig. 3   Riparian sediment source and stream aggradation in Dart River

Fig. 4 Upper Baton River, very low density of landslides

b) Upper Motueka River

The upper Motueka River (above Blue Glen Creek) has considerable evidence of active erosion on ultramafic rocks, in the form of gullies, landslides, and extensive bare ground subject to surface erosion by wind and water (Figs. 5 and 6). Gullying is extensive and occasionally severe (Fig. 5). Areas underlain by Maitai Group sediments appear far more stable, are dominantly forested, lack gullying and have a low density of landslides. Recent active sedimentation of stream channels is prominent (Fig. 6).

Fig. 5 Severe gullying of ultramafic rocks in upper Motueka; note the contrast with forested Maitai Group sediments to right of the photo.

Fig. 6 Active gullying, bank erosion and surface erosion in upper Motueka. Note the active sedimentation of the stream channel and the contrast in vegetation cover and erosion with the Maitai Group sediments in the background of the photo.

c) Bank erosion

Bank erosion ranges from prominent, large features (Figs. 7 and 8) found in a few sites along the major tributary stream channels (e.g. lower Motupiko near Quinneys Bush, Tadmor River near Tui) to frequent small bank failures along many stream channels. The relative significance of these small and large failures to sediment supply is hard to estimate since the large features have a high sediment supply capacity but are areally very limited, whereas the small features have a low sediment supply capacity but are areally extensive. It is interesting to note that:

- much work carried out as part of the Motueka catchment control scheme has focused on bank stabilisation of the small features (A. Burton, pers. comm. 2003).
- sediment yield from small catchments on Moutere gravel (e.g., at the former Moutere experimental station and Big Bush) is relatively low (<80 t/km^2/yr), whereas yield from moderate-large size catchments appears to be much higher (170 t/km^2/yr for the Stanley Brook, Hicks pers.comm. 2003), perhaps suggesting bank erosion from the higher order streams on Moutere gravels may be a significant source of sediment.

The large sources occur where the larger streams are incised into Moutere gravels, and often form cliffs 50–100m high (Fig. 7). They are probably old, natural landscape features that exhibit a range of activity. Some form vertical cliffs with little debris at the base and appear relatively stable. Others have gullied faces with debris cones at the base, indicating they are more active (Fig. 8).

Fig. 7 Severe bank erosion in the Motupiko River near Quinneys Bush

Fig. 8 Severe bank erosion in the Tadmor River near Tui. Note the gullying at the base of the cliff face.

2) Mapping of sediment sources

Digital orthophotos supplied by Tasman District Council have been used to locate and map all significant erosion features within the Motueka catchment using ARCINFO GIS. Any area of bare ground that was largely devoid of vegetation was considered a potential sediment source (we have not at this stage attempted to identify old erosion features that have now revegetated). These were identified on the orthophotos at 1:5000–10 000 scale and digitised, on-screen, as polygons. Future work will involve comparison of the larger and more important features with historic aerial photos (going back to the 1940s) to derive rates of change and volumetric estimates of erosion rates.

For each polygon the following attributes were recorded

- erosion type: landslide scar (L), sheet erosion (Sh), scree (S), bare rock (R), gully (G) and bank erosion (B). One further category, island (I), was required so that we could eliminate 'islands of vegetation' within a polygon and thereby avoid overestimating the total area of bare ground.
- the nature of the substrate. Four types of substrate were identifiable from the orthophotos- rock (K), soil (S), regolith and scree (R), and alluvium(A).
- an assessment of the connectivity of the erosion feature to a stream channel. The letter 'N' was used to denote that it was not connected while 'connected features' were assigned a number between 1 and 6 denoting the stream order of the channel to which the feature was connected.
- the presence or absence of vegetation. The letter 'N' was entered for features devoid of vegetation. Where vegetation was present this was entered as a percentage of cover.

Each polygon has a unique numerical identifier and the area can be calculated by ARCINFO.

We have digitised c.2000 erosion polygons from 23 orthophotos covering the headwater reaches of the Wangapeka and Motueka catchments where the aerial reconnaissance indicated a high density of erosion features. Results of some of the mapping are shown in Figs. 9 and 10.

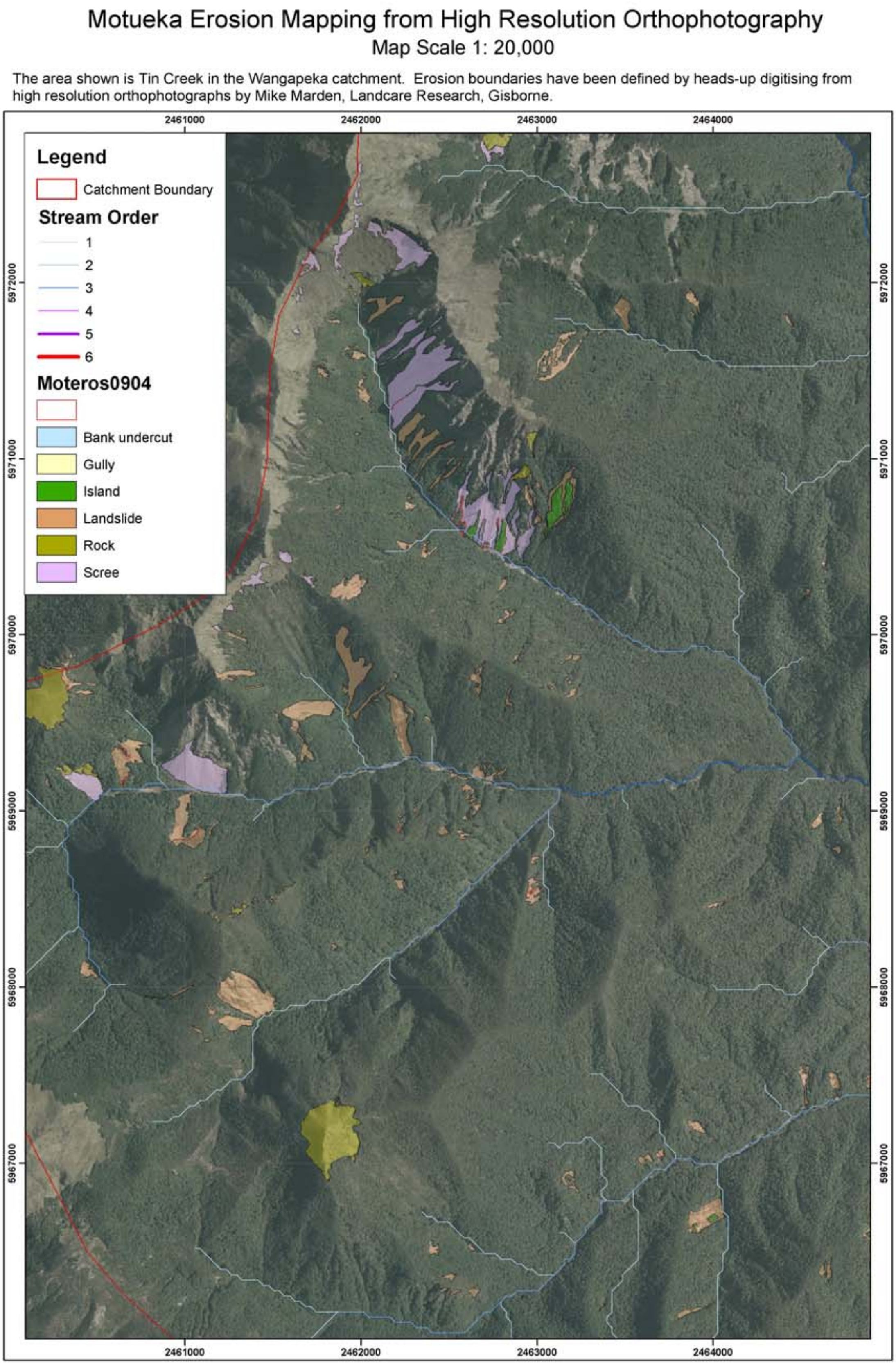

Fig. 9 Mapping of erosion features in a forested area of the headwaters of the Wangapeka

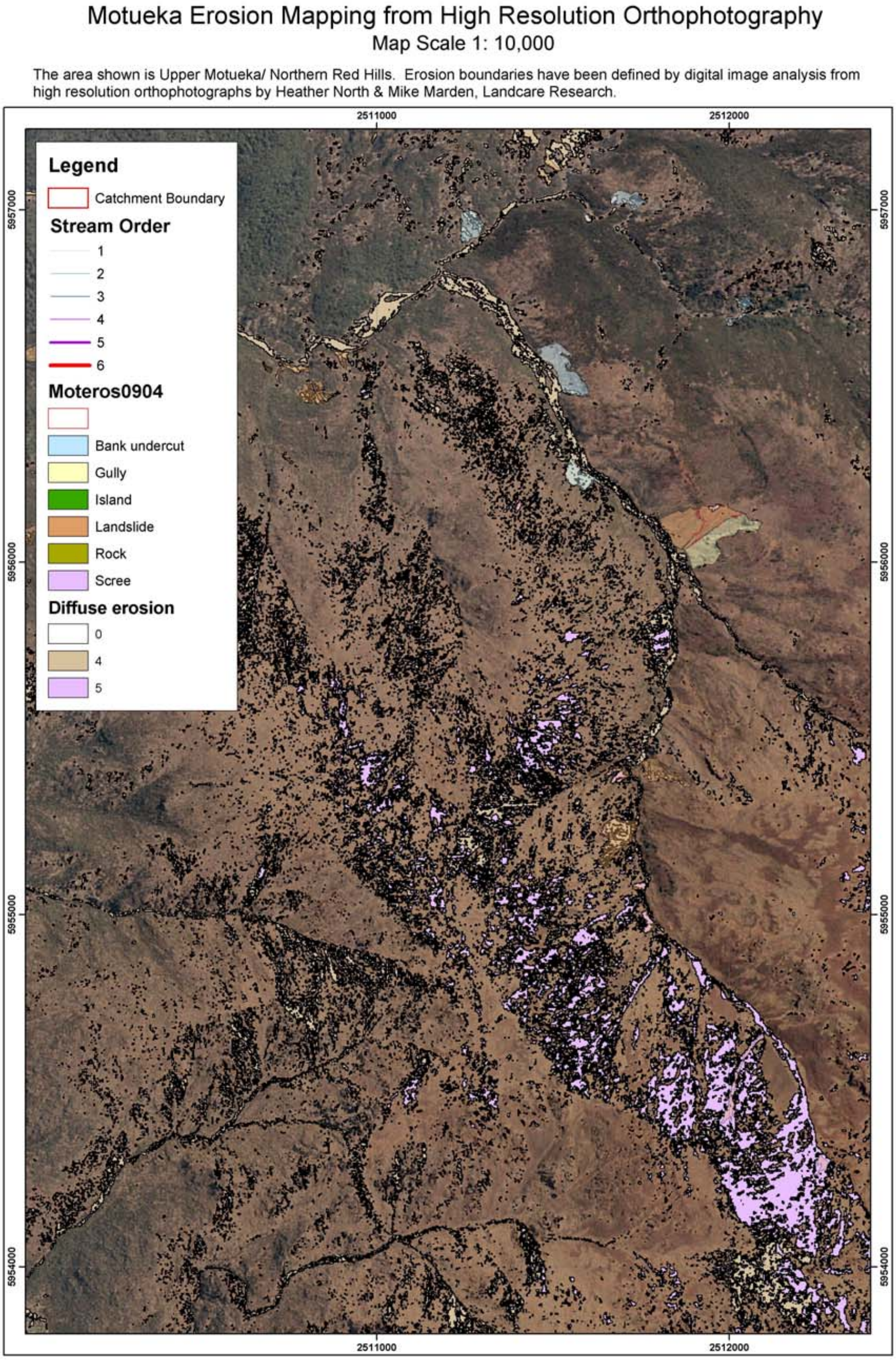

Fig. 10 Mapping of erosion features in the headwaters of the Motueka River (this map shows the delineation of diffuse erosion and point sources such as gullies and landslides)

In areas of extensive sheet erosion, mapping by visual interpretation and on-screen digitisation was slow. As an aid to this process, several tiles of digital orthophotography were mapped by an automated method using the remote sensing software package Imagine[2]. The method classifies each image pixel according to its colour. The first step was to visually identify the classes of interest (scree/rock, soil, shadow and several classes of vegetation) and define them according to their colour. The software then used these small training areas to classify the remainder of the image. Fig. 11 shows the result for a 1000 × 800 m portion of an image tile in the headwaters of the Right Branch Motueka (the full tile covers 5 × 7.5 km).

This automated process is suitable when the classes of interest can be differentiated by colour alone, but it does not use higher level identifying features such as object texture, shape or proximity to other objects, in the way that a human interpreter does. Topographic shadowing and radiometric fall-off within the image can disturb the unique relationship between a landcover class and its colour. Thus we defined both sunlit and shaded versions of each class, and lumped the two after classification. Radiometric variation from one aerial photograph to another also means that classes and their colours must be defined for each tile separately.

Because of these limitations, automated classification is not often used with aerial photography (as distinct from satellite imagery which is radiometrically stable and can be corrected for effects like topography much more easily). Fig. 11 includes several areas that are so deeply shaded areas their landcover class cannot be determined. Also, two topographic aspects are shown. Visual inspection of the classification indicates a degree of underestimation of soil and scree areas on the aspect that is less sunlit.

Despite this, the result may be useful as an adjunct to visual interpretation. Manual digitisation aims to place a boundary around areas that are homogeneous in erosion intensity (rather than round individual erosion scars). This judgement can be made more easily from the classified result than from the aerial photograph. The percent bare ground within that manually-drawn boundary can then be automatically calculated from the classified image.

[2] Maximum likelihood supervised classification in Erdas Imagine.

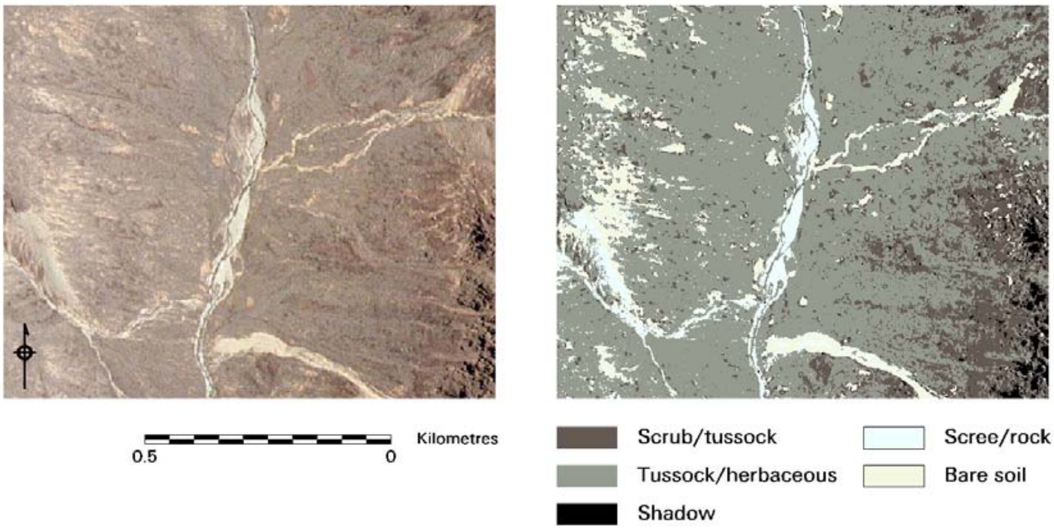

Fig. 11 1000 × 800 m area of digital orthophotography in the headwaters of the Right Branch Motueka (between Porter Ridge and Red Hills Ridge), and the classified result.

Some observations from the mapping of sediment sources on the orthophotos are listed below:

a) Native forest areas of upper Sherry, Tadmor catchments

Easy, low-relief, forested areas with few point sources of sediment. Sediment sources are predominantly shallow, soil slips on convex and linear slopes immediately adjacent to stream channels. A high proportion of these had direct connectivity to streams however they are predominantly small size and numbers are low. Most were probably generated during heavy rainfall events either as a consequence of elevated pore water pressures or by slope undercutting during periods of flood flow. In contrast to stream reaches downstream of the observed upper catchment reaches, channels in the upper catchment don't appear to contain large quantities of stored gravel. One has the impression that stream beds are stable, possibly armoured, thus much of the slope-derived sediment from the forested upper catchment is likely mobilised and delivered downstream at the time of generation.

b) Red Hills

Predominantly a large area of diffuse erosion of exposed soil, rock and colluvium within patchy, low-stature scrubby vegetation in a steep and rugged terrain. These diffuse areas collectively represent a potentially significant source of sediment generation and mobilisation by slopewash, wind and creep processes. However as most are far removed from stream channels it is unlikely that they are a significant contributor to stream sediment yield in the short term. There is evidence of recent storm-initiated landslides but few of their debris tails reach a stream channel. The principal source of sediment is from slump and gully point sources. These appear to coincide with thick deposits of colluvial materials, possibly of glacial origin, or zones of severely faulted and crushed bedrock. They occur at the base of slopes immediately adjacent to stream channels. Slumping is possibly caused by lateral stream erosion during periods of high flow.

c) Wangapeka

Steep, predominantly forest-clad, mountainous terrain. The most predominant sediment source is landslides located on slopes in excess of 35 degrees and within first and second order stream reaches. More than 90% of the landslides have direct connectivity to channels. The delivery ratio of sediment derived from these landslides is very high (i.e., unlikely to be any on-slope storage component or debris tail). Similarly, the delivery of sediment from 1st and 2nd order streams to 3rd order and larger streams will be high. There is not much storage capacity in these steep mountainous torrents.

Rock spalling is keeping some scree slopes active. Scree toeslopes probably only contribute sediment to channels when undercut during flood flows. Most scree slopes have direct connectivity to channels.

Bank undercutting is not important in upper stream reaches but reworked terrace alluvium will become more significant further downstream of the area looked at to date. Sheet erosion is present on a small scale above the treeline, but there is usually a thick forest buffer below the source so this is not likely to be a significant contributor of sediment to streams.

There are significant flat-floored gravel reaches in some of the non-torrent tributaries of the Wangapeka where a great deal of sediment of historical origin is stored. This is likely to be reworked from time to time, particularly during the larger flood events.

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